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Few-electron correlations after ultrafast photoemission from nanometric needle tips

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Free electrons are central to such diverse applications as electron microscopes, accelerators, and photo-emission spectroscopy. However, space charge effects of many electrons are often problematic and, when confined to extremely small space-time dimensions, already two electrons can interact strongly. Here, we demonstrate that the resulting Coulomb repulsion can also be advantageous, as it leads to strong electron-electron correlations. We show that femtosecond laser-emitted electrons from nanometric needle tips are highly anti-correlated in energy because of dynamic Coulomb repulsion, with a visibility of 56%. We extract a mean energy splitting of 3.3 eV and a correlation decay time of 82 fs. The energy-filtered electrons display a sub-Poissonian number distribution with a second order correlation function as small as g(2) = 0.34, implying that shot noise-reduced pulsed electron beams can be realized based on simple energy filtering. We also reach the strong-field regime of laser-driven electron emission and gain insights into how the electron correlations of the different electron classes (direct or rescattered) are influenced by the strong laser fields. Furthermore, we will also briefly show very recent results of coherent electron acceleration with laser light on a nanophotonic chip, with significant energy gain.

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